A SUMMARY OF THE ENVIRONMENTAL AND HYDROGRAPHIC CHARACTERISTICS OF THE MEDITERRANEAN COAST OF ISRAEL

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INTRODUCTION

The summary of environmental and hydrographic data specified below was prepared for the assessment of the feasibility of deployment, operability and survivability of fish cages in open sea on the Mediterranean coast of Israel. The wave characteristics presented here are based on older measurements, gathered via visual and afterwards waverider buoy off Ashdod. These are currently being updated with data from newer and more modern directional equipment. The Mediterranean coast of Israel represents mainly a sedimentary unit within the Nile littoral cell extending from the Nile delta to the Haifa bay. Hence net sediment transport is both within and outside the surf zone directed northward parallel to the coastline in the region up to Netanya, and may change direction according to wave directions further North within the surf zone. Sea bottom is basically Nilotic (quartz) sands from beach to about –30m, beyond which sand is replaced by silt and clay. The sand size is decreasing in size from beach to its offshore boundary, becoming mixed with increasing portions of silt and clay beyond –20 m contour line.

1. WINDS

Average Year Intensity Distribution:

light winds (less than 10 knots)	**~ 81.4 percent of time**
fresh winds (11 to 21 knots)	**18.3 percent of time**
strong winds (22 to 33 knots)	**1.2 percent of time**
winds above 33 knots	**< 0.1 percent of time**

Average Year Directional Distribution:

77% of the **fresh** winds blow from directions W to N through NW.
77% of the **strong** winds blow from directions SW to W trough WSW.

Average Seasonal Distribution:

94% of the **strong** winds occur between November and March, and
60% of the **strong** winds occur in January and February.

2. WAVES

Average Year Deep Water Characteristic (i.e.Significant - via Spectral Analysis) Wave Height Distribution:

low sea states (less than 1 m)	50.0 percent of time
moderate sea states (between 1 m and 2 m)	25.0 percent of time
strong sea states (between 2 m and 4 m)	20.0 percent of time
high sea states (above 4 m)	5.0 percent of time

Average Year Directional Wave Distribution:

All moderate and higher sea states come from WSW to NNW through W

66% of all waves approach from W trough WNW directions.

The highest sea states approach from W direction, but storm development occurs by veering from WSW to NW trough W directions.

Peak Wave Periods:

Peak wave periods range between 3 and 15 seconds. During high sea states they range usually between 10 and 13 seconds, and very high sea states have peak periods between 12 and 15 seconds.

Extreme Sea States and Average Return Periods:

Average Return Period	Deep Water Characteristic Wave Height
[years]	[meters]
2	5.15
4	5.95
5	6.15
6	6.25
8	6.60
10	6.80
15	7.15
20	7.40
50	8.20
100	8.70
500	10.15

Estimated extreme relationship between maximum and characteristic wave height in a given sea-state:

$$H_{\max} = 2 \cdot H_{m_o}$$

Accepted Risk to Encounter Design Wave	Economical Life Time of Structure (years)						
[percentages]	2	4	6	8	10	15	20
	Average Return Period to be Used						
1	200	398	597	796	995	--	--
5	39	78	117	156	195	293	390
10	19	38	57	76	95	143	190
20	10	18	27	36	45	68	90
50	4	6	9	12	15	22	29
64	2	4	6	8	10	15	20

Average Yearly Number of Storms and Their Average Duration:

Sea State of the Storm Crossing the Specified Level

Sea State Exceeded Hmo>=	Average No. of Storms	Average Duration of the Sea State per Storm	Standard Deviation of the Storm Duration
[m]	[-]	[hours]	[hours]
0.5	79.34	90.5	127.31
1.0	59.63	39.7	44.15
1.5	33.56	35.2	35.33
2.0	24.90	29.2	29.26
3.0	9.90	24.4	20.00
4.0	5.10	16.2	13.43
5.0	1.25	12.2	9.40
6.0	0.25	5.3	4.76

Sea State of Storm Crossing Specified Level & one 1 m Higher

Sea State Exceeded Hmo>=	Average No. of Storms	Average Duration of the Sea State per Storm	Standard Deviation of the Storm Duration
[m]	[-]	[hours]	[hours]
1.0	19.69	78.35	44.29
1.5	12.50	62.77	37.26
2.0	8.94	54.36	30.49
3.0	4.44	39.90	19.22
4.0	1.25	31.99	9.78
5.0	0.25	23.65	12.36

Sea State of Storm Crossing Specified Level & one 2 m Higher

Sea State Exceeded Hmo>=	Average No. of Storms	Average Duration of the Sea State per Storm	Standard Deviation of the Storm Duration
[m]	[-]	[hours]	[hours]
1.0	7.94	100.88	51.18
1.5	5.63	79.64	41.04
2.0	4.19	70.28	32.61
3.0	1.19	54.38	20.26
4.0	0.25	40.00	14.59

Sea State of Storm Crossing Specified Level & one 3 m Higher

Sea State Exceeded Hmo>=	Average No. of Storms	Average Duration of the Sea State per Storm	Standard Deviation of the Storm Duration
[m]	[-]	[hours]	[hours]
1.0	3.94	119.70	108.77
1.5	2.50	96.91	48.13
2.0	1.19	80.84	28.68
3.0	0.25	68.10	32.83

3. SEA LEVELS AND TIDES

Tidal range varies between 0.4 m during spring tides, and 0.15m during neap tides. Extreme sea levels may occur in combination with extreme meteorological conditions. Based on 30 years of data, the following average return periods are assessed:

Average Return Period	Low Sea Level	High Sea Level
[years]	[m]	[m]
1	-0.38	0.64
50	-0.74	1.04
100	-0.87	1.10

The above values do not include the expected sea-level rise due to the "greenhouse effect", for which the assessed values for 2100, range between 0.1 m and 0.9 m. This value is a world wide average rise, while the relative regional value may differ significantly due to additional various factors, such as plate tectonics. So far it is not clear yet what are the expected sea-level rise values for the Mediterranean in general and for the coast of Israel in particular.

4. CURRENTS

Tidal Currents:

Tidal currents in this region are in general weak, in the order of about 5 cm/second.

Wave Induced Currents:

These currents prevail and are predominant within the surf zone. Longshore currents are induced by waves approaching obliquely to the contour lines, and flow parallel to the shore line. Rip currents are generated by perpendicular waves or edge waves, and flow from the shore offshore, almost perpendicular to shore line to a distance of up to about 3 times the surf zone width, within which they decay completely. The former may attain during storms speeds of 4 knots and even more, The latter may also attain 1 to 2 knots, but also in calmer sea states.

General Circulation:

In this region, the general circulation, due mainly to the geostrophic current and shelf waves, is oriented counter clockwise most of the time. The currents in most cases have low speeds of about 10 cm/sec. The vertical distribution is almost uniform in winter, but decays towards the bottom in summer. The speed decreases towards the shore. In certain instances, currents of about 2 knots were measured.

5. SALINITY AND WATER DENSITY

The salt content lies around 38 promill and varies between winter and summer. The sea water specific weight under normal temperature conditions is about 1.0265 ton per cubic meter.